ROTCH (T. M.)

From the Author.

ABSENCE OF RESONANCE IN THE FIFTH RIGHT INTERCOSTAL SPACE,

DIAGNOSTIC OF

PERICARDIAL EFFUSION.

By T. M. ROTCH, M.D.
OF BOSTON.

Reprinted from the Transactions of the Massachusetts Medical Society.

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My attention was first directed to the investigation of the commonly received views concerning the area of dulness in pericardial effusion, by the numerous cases of effusion into the pericardium found at post-mortem examinations, where such effusion had not been diagnosticated during life, although the patients had been in the hands of most competent clinical diagnosticians.

On inquiry, I learned from very careful investigators, that the rules laid down by authorities on this subject were often totally inadequate for purposes of diagnosis, and the opinion of these physicians is well represented, when expressed in the words of Professor Calvin Ellis, who, when questioned regarding the subject, said that "he thought the rules laid down by authors for determining pericardial effusion by the pyramidal form of the area of flatness, misleading and insufficient." Dr. Henry I. Bowditch also concurs in this opinion.

Influenced by the experience of these eminent physicians, I began, about nine months ago, a series of experiments to determine, if possible, the actual shape which the effusion, when present, *does* take, and the results of these experiments will be given in this paper.

What, then, are the views held upon this subject by the numerous authorities, who have written about it since Galen, Forestus and Rondelet first spoke of pericardial effusion?

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* Read at the Annual Meeting of the Massachusetts Medical Society, June 11, 1878.

Albertini, and in like manner Morgagni mention the difficulties presented in the diagnosis, while Auenbrügger first gave the symptom of præcordial percussion dulness, Laennec at the same time doubting the possibility of diagnosticating pericardial effusion with any certainty, and this author did not recognize the disease by percussion, Louis being the first French author who speaks of it, while præcordial dulness, as a symptom, is first elaborately described by Skoda and Kolletschka.

We will not here consider the various complications of the disease which may arise and render its diagnosis of greater difficulty; these I expect to speak of in a future paper, considering at present merely the diagnosis by percussion of a simple serous or sero-fibrinous effusion into the pericardium, with the heart healthy or diseased as a complication, but the lungs and pleura normal, no adhesions, and in fact nothing else abnormal in the thorax or abdomen.

Reviewing the ideas of representative authors on this subject, first, Skoda writes, "It is necessary to have a large amount of fluid to cause an increase of dulness. The dulness depends on the amount of retraction of the lung.

"As the heart is heavier, that is, has a greater specific gravity than any exuded fluid, it lies as deeply as possible, the fluid standing as high as possible; this is when the fluid is in small amount, and is always the case excepting when the pericardium is relaxed, or when adhesions are present in the upper part of the pericardium; thus at first when the amount of fluid is comparatively small, the increase of the dulness is vertical, that is, in the long diameter of the heart, while increase in breadth only takes place after the amount of fluid has increased still further, and when it reaches 1,000 cubic centimetres, as a rule the percussion dulness extends from the second left costal cartilage to the lower edge of the thorax, and in breadth from the right edge of the middle piece of the sternum to the left axillary line."

Stoffela, reporting Oppolzer's lectures, says: "The symptoms of pericardial effusion are in some cases very evident, while in others they are so unpronounced as to cause the greatest difficulty in the diagnosis. Percussion shows that the exudation begins at the base of the heart, where the great vessels join the heart, and hence as the pericardium at this point is most relaxed, so the fluid collects here first and is first found here by percussion, thus increasing the long diameter of the heart, reaching as high as the third or second rib, in the left parasternal line; then, on the fluid increasing, we find the dulness increased in breadth, that is, extending from the right edge of the sternum across to the left mammary line; this area of dulness has the form of an inverted triangle, its base being upwards and its squared apex downwards; then, on further increase of the effusion, the dulness can extend up to the first rib, and the figure becomes less and less like a triangle, but, as it increases, the fluid fills up the lower part of the pericardium, and we now have a triangle, with the base downwards and its truncated apex above."

Prof. Bauer says, "that the effusion first collects at the base of the heart, pushing that organ downwards before it; that the dulness has in a majority of cases a certain form, namely, that of a truncated cone with the base downwards," and he disagrees with Duchek, who holds "that the form of the area of dulness is determined by the lungs retracting," while Bauer contends "that it is the shape of the pericardium itself which governs this form." Bauer also says, "that in large exudations the triangle reaches to the second or third rib on the left of the sternum, that at times the whole sternum may be dull, that the left side of the triangle may extend beyond the left nipple to the axillary line, and that this may also occur on the right side; usually, however, the dulness extends very little to the right of the sternum, and the effusion must have reached 100 cubic centimetres in quantity before a diagnosis can be made."

Paul Niemeyer states, that the exudation is first perceptible by percussion, when it has reached 250 cubic centimetres, and both he and Kunze agree with Oppolzer as to the form of the area of percussion dulness, while Guttmann, Felix Niemeyer, Gerhardt, Jaccoud and Gee appear to agree with the views of Skoda on this point.

Sibson, writing in Reynolds's "System of Medicine," says, "the fluid collects in the lower part of the percardium, pushing the heart up, so that the apex is above and beyond the nipple, and when the effusion is large it assumes a pyramidal or pear shape." He also considers, as does Gee, that it is the vertical increase of dulness which is characteristic of pericardial effusion, as affording the means of diagnosis from an enlarged heart.

Da Costa states that the shape is "pyramidal," with the base downwards; while Flint speaks of the area of dulness as "pyriform," with the apex at the sternal notch, and the base at the 6th or 7th cartilages, the left boundary extending as far as the left nipple, and the right over the right edge of the sternum.

The rules for making the diagnosis of pericardial effusion, then, being exactly laid down by these authors, have they, or have they not, proved adequate, practically, for such diagnosis? The following instances will, it seems to me, tend to show that they have not.

First, I would cite the case reported to me by Professor Ellis, where the diagnosis of pericardial effusion was made by one of the best trained of his advanced students, strictly according to rule, and so logically drawn up that Professor Ellis could not gainsay the diagnosis, so long as he admitted the triangular form of flatness to be characteristic of pericardial effusion; and yet there was no doubt, judging by other prominent symptoms, that the area of increased præcordial flatness was caused by an enlarged heart.

Next, by permission of Dr. T. B. Curtis, I will read an extract from his letter to me on this subject, giving his reasons for doubting the correctness of the established rules for diagnosticating effusion. Dr. Curtis says: "When I was serving as interne in 1870 at the 'Hôpital des Enfants Malades,' under Dr. Henri Roger, there was in one of his beds a little girl about five years old, who presented all the signs of an abundant chronic effusion into the pericardial cavity. We had her several weeks under observation, and she was an object of particular interest to Dr. Roger, for the reason that he had already previously practised puncture of the pericardium in a well known case (published in the 'Union Medicale,' December, 1868), and was extremely desirous of an opportunity to repeat the procedure.

"In this case indications of the operation seemed to present themselves again, at times in the most urgent manner. Repeatedly I saw Dr. Roger mark out the area of dulness in his usual minutely careful way, and select the exact spot where he would insert the trocar. Before deciding to operate, he consulted Dr. Labric, who was also attached to the Children's Hospital, and for whose judgment he had the highest regard. The latter, however, persistently advised against the proposed puncture, and in deference to his opinion the operation was postponed, until finally the child succumbed, without the operation having been performed. At the autopsy we found no effusion, but an enormously dilated heart.

"So closely, then, in this case were the signs of a copious pericardial effusion simulated by dilatation of the heart, as to deceive one so skilful as Dr. Roger, fortified by an experience of nineteen years as physician to the Children's Hospital, a virtuoso in the art of physical examination, the author together with Dr. Barth of a well known treatise on auscultation and percussion, and also author of a treatise on the semeiology of childhood."

Allowing that the heart has been tapped by mistake, by Baizeau and Roger, and blood withdrawn from the right ventricle without apparent harm to the patient, yet this accident is not by any means devoid of danger; and to show the great risk incurred in tapping the heart to the left of the sternum, with only our present knowledge of the signs of effusion, I will present one more instance of unsuccessful diagnosis. In the "Gazette des Hôpitaux," No. 39, there is reported the case of a soldier in the Military Hospital of "Groscaillon," who exhibited symptoms of pericardial effusion and disease of the aortic valves following from attacks of acute articular rheumatism. The dyspnœa led the surgeons to introduce a No. 1 Potain needle in the third left intercostal space, to the depth of four centimetres. No fluid appeared, and on leaving the needle free it oscillated synchronously with the beat of the heart, which had been punctured; the patient uttered a sharp cry, took one deep inspiration, and was dead. The pericardium was found to be much thickened and adherent to the heart at various points. The needle had passed over one of these points and wounded the central organ.

The experiments which I am about to present to you were performed in the Physiological Laboratory of Professor H. P. Bowditch, and were all submitted to his inspection. I am greatly indebted for very valuable suggestions from Professor Bowditch, from his assistant Dr. Garland, and from Dr. James J. Putnam.

My first experiments were made upon dogs, but were failures, as to any notable results, for the following reasons: 1st, that the dog's pericardium has not the same shape as the human pericardium; 2d, that it hangs more vertically in the thorax; and 3d, that owing to the pleura meeting directly in the median line of the sternum, and to the existence of an extra pleural cavity under the heart (first spoken of by Dr. Garland), it is impossible to enter the pericardium

without opening the pleural cavity and causing collapse of the lung, an accident which materially alters the shape which the fluid may assume.

It was therefore thought best to use the cadaver only; for here we can introduce fluid into the pericardium without destroying the relations between the lungs and the heart which exist during life; it was also found by dissection that the anatomy of the infant's thoracic organs corresponds so very nearly to that of the adult's, that the introduction of fluid into the infant's pericardium was followed by the same relative results as that into the adult's.

My results are based upon the injections of sixteen infants and four adults. The fluid used was melted cocoa butter, which has a specific gravity of 0.90. It will be well to state here that I use the term flatness to express entire absence of resonance, or what is understood by some German authors as "absolute dulness." By relative dulness I mean diminished resonance. Thus when I speak of the *flatness* of the heart or effusion, I mean that no lung tissue whatever is between the pleximeter and such heart or effusion; while, where there is more or less lung tissue, I use the term *relative dulness*. Now as opinions are much more apt to differ as to relative dulness than as to flatness, it is the *area of flatness* which I shall mark out as characteristic of effusion, and I would also add, that in order to mark out the boundary of the area of flatness correctly, we must percuss very lightly from a point of established flatness, such as the fifth left costal cartilage, to the right and left and upwards, until we come to the encircling resonant border of the lung.

It is needless to mention the various methods of entering the pericardium which were employed before satisfactory results could be obtained; it is sufficient to state, that although by sawing the sternum in the median line the pericardium can be entered without perforating the pleural

cavity, yet that by this method the results of percussion are rendered void by air not only entering the anterior mediastinum, but also getting into the pericardium itself.

The method which was finally adopted was as follows: The subject was placed in the position of orthopnœa, that is, the trunk was bent upon the lower limbs, at an angle of about 120 degrees. Tracheotomy was performed and a clamped rubber tube attached to the glass tracheal tube. The lungs were then inflated, until the area of heart flatness corresponded to that marked out in Diagram I., which is copied directly from Luschka's plate, and is, as is stated by Luschka, intended to represent the parts in expiration.

After inflation, the tracheal tube was clamped, so as to keep the parts in position, and an incision was made in the median line of the abdomen, up to within two centimetres of the ensiform cartilage; the liver and stomach were next gently drawn aside, and on palpation of the central tendon of the diaphragm, four centimetres below the upper edge of the diaphragm and about two centimetres to the left of the median line, the heart was felt. This part of the diaphragm was then carefully drawn down away from the heart, in order that that organ should not be punctured, and a dagger-pointed trocar, previously filled with melted cocoa butter so as to displace the air, was plunged through the diaphragm into the pericardial sac; at the same time an assistant unclamped the tracheal tube, in order that the lungs might be free to retract before the fluid.

When sufficient fluid had entered the pericardium the cocoa butter tube was clamped, as was also the tracheal tube. The thorax was then carefully percussed and the line of flatness marked in ink. After twenty-four hours the sternum was removed from above downwards, remaining attached below, and we had before us the lungs in position surrounding the hardened fluid, and by replacing the sternum and comparing the line previously marked in ink, by means of

needles, with the line of the lung around the effusion, we arrived at very accurate results regarding the shape of the area of flatness.

The fact that on opening the abdomen the diaphragm remains arched, and that the lung by means of the tracheal clamp retains its position and does not collapse, warrants us in assuming that we can fairly judge of the position of the fluid during life by this method of investigation, especially as the contractility and distensibility of the lung appear to be perfectly retained after death, excepting in very cold weather, when it was found necessary to warm the cadaver.

The apparatus for the cocoa butter is a simple wash bottle, graded for cubic centimetres.

We must now shortly consider the anatomy of the normal pericardium and its relation to the heart and lungs. This, so far as the adult is concerned, I have taken mostly from Ferber, Luschka, Sibson and Shrœtter; while in regard to the infant, I have made my own dissections, comparing the thoracic organs with those of the adult, and finding, as I have above stated, the relation of the parts so nearly approximating each other in the two, that the rules which govern an effusion in one answer for the other.

According to Shrœtter and Luschka, in the normal condition of the thoracic organs, on expiration, we have the flatness of the heart beginning at the junction of the upper border of the fourth left costal cartilage, extending outwards and downwards to the left in rather a curved line, with the convexity outwards, and keeping from two to three centimetres within the nipple, until it joins the flatness of the left lobe of the liver; from the same starting point at the fourth cartilage, it extends down the left parasternal line, or perhaps a little within that line towards the middle of the sternum, until it reaches the liver, as seen in Diagram I. This figure is at times triangular, especially on deep expiration. We there-

fore may have a triangular area of flatness over the normal heart, though it is usually quadrangular. Next, supposing that the lungs are removed, we then have exposed to view the pericardium as seen in Diagram II., represented by the area A, and copied directly from Ferber's "Situs Phantom." The base of the pericardium is attached to the central tendon of the diaphragm, extends upwards enveloping the heart, and is attached to the great vessels of the heart between the first and second ribs, spreading out on either side of the sternum in pyriform shape, most markedly on the left side of the sternum, but keeping within the mammary line.

The lower border of the upper lobe of the right lung approaches the right edge of the sternum at about the level of the fourth rib; on the left side, the upper lobe passes around the heart down nearly to the sixth rib; the middle lobe of the right lung, in the region between the right mammary line and the sternum, extends from the fourth to the sixth rib, where the line of the liver flatness begins. This amount of anatomy is sufficient for our purpose at present.

First, we will consider what takes place when we introduce a small amount of fluid into the pericardium, picking out from my notes a case which may be regarded as typical. Jan. 7, 1878, injected by the usual method, through the diaphragm, a small amount of fluid into the pericardium of an infant of from one to two weeks old. Percussion gave an increase of præcordial flatness, as follows: beginning at the sixth rib, about two centimetres to the right of the sternum, it passed upwards in a curved line with the convexity outwards to the fourth right costal cartilage at its lower edge, then across the sternum to the upper border of the fourth left costal cartilage and outwards and downwards to and to the outside of the nipple, passing down to the sixth or seventh rib, as is seen in Diagram III. There was no vertical increase of flatness. This line of flatness then was a semicircle, with its convexity upwards, and with the

radius of that part of the curve which was to the right of the sternum shorter than that which was to the left. What was this flatness caused by? On clamping the trachea and removing the sternum, the area of flatness, marked out in ink, was found to correspond to that part of the pericardium which was uncovered by the lungs: it was found that the lower lobes had retracted before the fluid, and that the fluid had taken the shape which is represented in Diagram III., the normal physiological flatness of the heart forming the upper part of the area of flatness, and the effusion the lower part. The lungs were then drawn aside and the pericardium, with its contained effusion, was seen to present the form which is shown in Diagram IV., the effusion apparently being drawn up at the sides, where it was thickest, leaving a thin layer below, so that the broadest part of the effusion about corresponded to the top of the curved line. The same result, as to the area of flatness, was obtained whenever a small amount of fluid was introduced, whether in the infant or adult, the increase always being in a line with the lower part of the sternum, and never vertically.

Perhaps it will be well to here describe shortly the case where I was enabled to determine the first signs of effusion in an adult, by the introduction of from 70 to 80 cubic centimetres of fluid, which is from 20 to 30 cubic centimetres less than the smallest amount laid down by authors as being possible to make a diagnosis by.

April 22, 1878.—subject, a female of medium size, who had died of cancer of the rectum: percussion of lungs and heart normal; resonance in fifth right intercostal space well marked. Dr. Maurice Richardson managed the cocoa butter apparatus for me, keeping his eyes on the graduated scale and his hand on the clamp; the trocar was introduced, and I proceeded to percuss lightly the fifth right interspace about 1½ to 2 centimetres from the edge of the sternum, until decided flatness was found and verified by Dr. Richardson,

who then immediately applied the clamp, when we found by our scale that when the flatness first appeared 70 to 80 cubic centimetres of fluid had been introduced. We then found that no vertical increase of flatness had taken place, and that the curved line bounding the area of flatness corresponded to that in Diagram III., the percussion flatness extending in the fifth interspace to about 4 centimetres from the edge of the sternum.

Next we will consider the large effusion, where the pericardium is pretty well filled from top to bottom.

May 10, 1878, with the assistance of Professor Bowditch, injected the pericardium of an infant about two weeks old, until percussion showed that the præcordial flatness had extended to the nipple on the right, and beyond the nipple to the left, in an area corresponding to the front of the thorax as high as the fourth ribs, when it approached the sternum to within about 1½ centimetres, and then passed upwards to the sternal notch.

The distended pericardium, with the lungs removed, is represented in Diagram II. by the area A and D.

Diagram V. represents the picture, disclosed to our view, on clamping the trachea and removing the sternum, in the case where the pericardium was spoken of as filled, and is drawn directly from the cadaver. The exact amount which must be injected before an increase of vertical flatness is obtained, I have not yet determined. It may be objected, that the fluid was introduced at the bottom of the pericardium, while naturally it should start at the base of the heart. In my earlier experiments I *did* introduce the fluid where the pericardium is reflected over the great vessels, but even when it was in very small amount and quite insufficient to cause any increase of percussion flatness, it immediately ran down the side of the heart to the bottom of the pericardium, so that I cannot conceive of its collecting to any appreciable amount at the base of the heart and being retained there.

Even if it was retained there, it would not by its form represent an inverted triangle, as I have proved by inverting the cadaver and filling the upper part of the pericardium, when the resulting cast always had its broadest part directed towards the diaphragm. Nevertheless, as the convictions of some of the greatest clinical observers on this point are very decided, we must, in deference to their opinion, wait until more extended clinical facts are brought to bear on the subject, before eliminating flatness at the base of the heart as diagnostic of the early stage of effusion in pericarditis.

As to the change of the position of the heart's apex spoken of by Flint and Reynolds, namely, that the apex is pushed upwards and outwards by a moderate effusion, so that the impulse appears in the fourth left intercostal space, I did not in my experiments find that this was the case, the apex being found by measurement to remain in its normal position; and in fact it seems highly improbable that a fluid, which according to Skoda always has a smaller specific gravity than the heart, should push that organ upward, a proceeding which would be quite contrary to the physical laws which govern the relation between a solid body and a liquid, when such body is suspended in the liquid and has a greater specific gravity than the liquid. By referring to Diagram III.—of the small effusion—it seems more plausible to account for the pulsation in the fourth interspace, by the tumultuous action of the side of the heart, which, as is seen in Diagram III., can approach the thoracic wall at this point, especially as it has been observed by Professors Ludwig and Bowditch that the impulse of the heart, as seen normally in the fifth left intercostal space, need not necessarily be caused by the heart's apex, but by a portion of the heart above the apex striking against the thoracic wall.

The whole question, however, depends on the correctness of Skoda's observation, that the heart must always sink in

a pericardial effusion as far as its attachments will allow, and this can only be determined by carefully taking the specific gravity of pericardial effusions of different densities and comparing them with the specific gravities of the fluids in which the suspended heart will float or sink. Skoda, however, is also incorrect in supposing that the small amount of fluid stands as high as possible in the pericardium, thus causing an increased vertical flatness, for in reality the lower part of the pericardium envelopes the lower part of the heart so loosely that the small effusion has plenty of room to collect in the lower part of the pericardium first, making an increased distension in breadth, and, as we have seen, appearing in the fifth interspace.

Before proceeding to discuss the general conclusions which we are warranted in assuming in regard to the diagnosis of pericardial effusion, we must consider what changes in the præcordial area of flatness may be due to changes in the heart itself.

For this purpose, it is not necessary for us to consider particularly whether the left or right side of the heart is hypertrophied or dilated: the question of interest to us, in this connection, is the result of all these conditions, that is, simply what possible part of the præcordia may be rendered flat on percussion by an enlarged heart; for I hold that we cannot as yet distinguish with sufficient certainty between the absence of resonance obtained on percussing over a fluid, from that obtained on percussing over a solid organ, such as the heart or liver, to warrant us in giving an opinion as to which is fluid and which is solid, and that therefore it is of the utmost importance to determine where the heart, if enlarged, might cause flatness, for this area must be taken into consideration, and subtracted from the whole area of flatness, before we are are justified in introducing a trocar expecting to find fluid.

In determining the possible area of percussion flatness caused by enlargement of the heart, I have consulted Bamberger, Oppolzer, Gerhardt, Shroetter, Paul and Felix Niemeyer, and finally Professor Adolf Weil, of Heidelberg, who has published some excellent plates on this subject. These authors all concur as to the extension of the flatness to the left of the left nipple, just as we have seen the effusion to extend. Oppolzer and Gerhardt speak of the possible increase of flatness upwards beyond the line of the fourth rib.

There is some difference of opinion as to the extension of the flatness to the right of the sternum. Shroetter contends that increase of flatness to the right of the sternum as diagnostic of enlarged heart is not nearly so frequent as is generally supposed, and gives as an instance of great increase in size two to five centimetres to the left of the left mammary line, and possibly two to four centimetres beyond the right edge of the sternum. Professor Ellis doubts if we ever find flatness beyond the right edge of the sternum, and says that it would be especially rare as low as the fifth interspace. Oppolzer says that the flatness may possibly reach one centimetre beyond the right edge of the sternum: the other authors either give the right edge of the sternum as the limit, or do not state definitely the part of the sternum where the flatness passes to the right. Weil holds that, even in extreme cases, the absolute dulness or flatness does not encroach on the fifth right intercostal space, while the relative dulness may extend over the right edge of the sternum for from two to three centimetres. The area of flatness of an enlarged heart represented in Diagram VI., gives the combined views of these authors, to even an exaggerated degree, so as to avoid all error, and it will be seen that the area of flatness, represented by A, does not enter, to any appreciable degree, the fifth right intercostal space.

All these authors consider that the form of the area of flatness of an enlarged heart is determined by the retracted border of the lungs.

Oppolzer and Kunze find that, in enlargement of the whole heart, a truncated triangle form of flatness is sometimes found. Weil also, in his plates, makes the area of flatness of an enlarged heart have a triangular shape. According to these authors' own testimony, then, we cannot consider the triangular or truncated pyramid form of the præcordial area of flatness decidedly characteristic of effusion, for both the normal and enlarged heart may assume these shapes.

On precise experiment, also, we find that the form of the area of flatness merits the name of a semicircle in the small effusion rather than a triangle or pyramid, and that the latter terms certainly would be misleading if applied to the large effusion as represented in Diagram V. Why then retain these misleading terms, which only tend to confuse us in our endeavors to properly appreciate the subject?

As, however, the effusion, as it varies in its amount will also vary in its form, it is wiser in making our diagnosis by percussion, not to seek for any particular shape, but to find a part of the thorax where flatness on percussion will be significant of effusion. Now the flatness found to the left of the sternum, that found in the vertical line, and possibly that found to the right of the sternum above the fifth rib, may occur and yet no effusion be present; we therefore eliminate all that area of flatness marked in Diagram VI., area A, and find that we have left, in both the small and large effusion, an *area of flatness in the fifth right intercostal space*, as represented in Diagram III. In this interspace the flatness first appears as characteristic of effusion. It probably also appears, at the same time, to the left of the sternum, but the physiological flatness of the heart here obscures it. For diagnosis, then, *flatness, at from two to three centimetres*

from the right edge of the sternum in the fifth intercostal space, would be almost absolutely sufficient to mark the presence of an effusion, unless the opinions of authorities, on enlarged heart, are proved to be incorrect; and I would here merely suggest, as it is a subject which I expect to treat of in a future paper, that puncture of the pericardium can safely be performed in the fifth right intercostal space, at from four and a half to five centimetres from the edge of the sternum, where the flatness, as is shown in Diagram III., extends even beyond the line E E′ E″, which represents, in Diagram VI., the relative dulness of the enlarged heart, according to Weil. At least it will be far safer, so far as the heart is concerned, to perform paracentesis at this point, than where it has been heretofore advised and practised by surgeons, namely, in the third, fourth and fifth left interspaces; for, as is seen in Diagram III., we may, in the third and fourth spaces, have our flatness caused by the physiological flatness of the heart, and by referring to the casts of cocoa butter, which I have preserved, we find that the layer of fluid, even when present, is thinnest over that portion of the præcordia and also in the part which corresponds to the fifth left interspace, while it is thickest at the sides.

There are a few points which it will be well to speak of here.

The lung seems to retract before the fluid, and it is the lowest part of the lung which first retracts, thus leaving a curved line of flatness with its convexity outwards.

The top of the area of flatness is almost on a line with the broadest diameter of a small effusion, as is seen by comparing Diagrams III. and IV.

Additional value is given to the diagnosis of an effusion by percussion, from the facts, that where an effusion is present, the friction sound need not necessarily have ever occurred: that the apex beat in effusion may be felt to the left and below the nipple, as in enlarged heart, extending

outwards as far as the line of flatness does, and vice versa; that at times the apex beat of an enlarged heart may be very feeble, and even imperceptible; also, that the rational signs of enlarged heart and pericardial effusion may be at times almost identical.

In conclusion, I shall describe as briefly as possible the extremely small number of clinical observations which I have been able to make during the past winter.

The first was a woman who died at the Channing Home. Flatness on percussion was found in the fifth right intercostal space to the distance of five centimetres from the edge of the sternum. There was no increase of vertical flatness. The autopsy showed the pericardium to be distended with about one hundred and twenty cubic centimetres of fluid.

The second case is especially interesting, as showing the difficulty which may be met with in the differential diagnosis between enlarged heart and effusion, without the aid of our *fifth right intercostal space*. This case, a boy six years of age, is best spoken of in connection with another, a girl eleven years of age, who was under observation at the same time, through the kindness of Dr. Davenport of the Children's Hospital. In both patients the same rational signs were presented, such as orthopnœa, præcordial pain, etc. In both cases the attack followed acute articular rheumatism. In both cases the force of the heart's impulse was of about the same intensity, and appeared to be a little to the left, and below the left nipple. The vertical flatness was not increased in either case; the area of flatness to the left of the sternum was identical in both cases. In the boy, however, flatness was found in the fifth right intercostal space, while in the girl it did not extend beyond the left edge of the sternum. In the boy a loud undoubted pericardial friction sound developed at the base of the sternum; in the girl a decided murmur developed at the apex of the heart. These last two symptoms are spoken of to show the strong

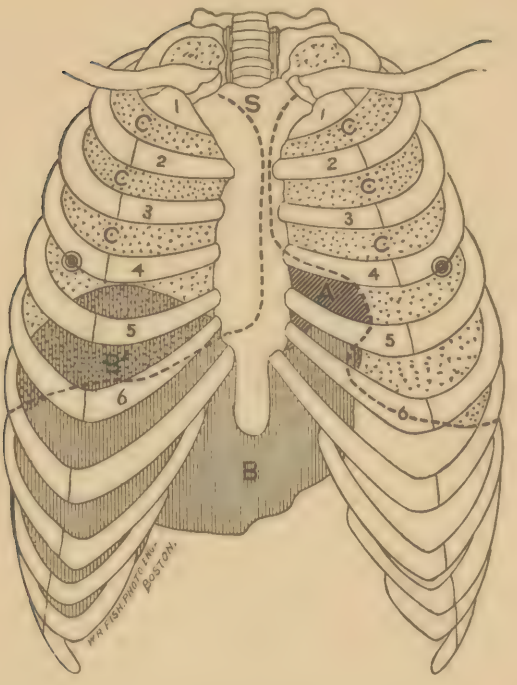
probability of the correctness of the diagnosis that the boy was a case of pericarditis, and that the girl was a case of endocarditis with enlarged heart, though of course this could only be proved by autopsy, and the cases must merely be taken for what they are worth: but, when we remember that the friction sound might have been absent, and that apparently endocardial murmurs may occur, where no disease of the heart itself, but merely a pericardial effusion is present, we again have to appeal to our *fifth right interspace* for diagnosis.

My third and last case was a patient seen at the City Hospital, whom, through the kindness of Dr. Doe, I was allowed to thoroughly examine. In this patient the area of percussion flatness verified by Dr. Doe, exactly corresponded to that marked out in Diagram III., and I made my diagnosis simply by the flatness in the *fifth right interspace*. The case was especially interesting from the fact that it illustrated Gerhardt's observation of the change of the area of flatness in effusion on change of position of the patient. When the patient was in the position of orthopnœa, we obtained the fifth interspace flatness: when she was horizontal, this flatness disappeared, leaving the normal resonance of the lung.

As additional proof that this was a case of pericardial effusion, an undoubted pericardial friction sound, testified to by several of the physicians at the Hospital, developed, and according to Professor Traube it is exceedingly rare to mistake this sound for a pleural friction sound.

DIAGRAM I.

Normal Thorax.



A—Physiological area of percussion flatness of the heart on expiration.

B—Liver.

B́—That portion of the liver which is covered by the right lung.

C—Lung.

S—Sternum.

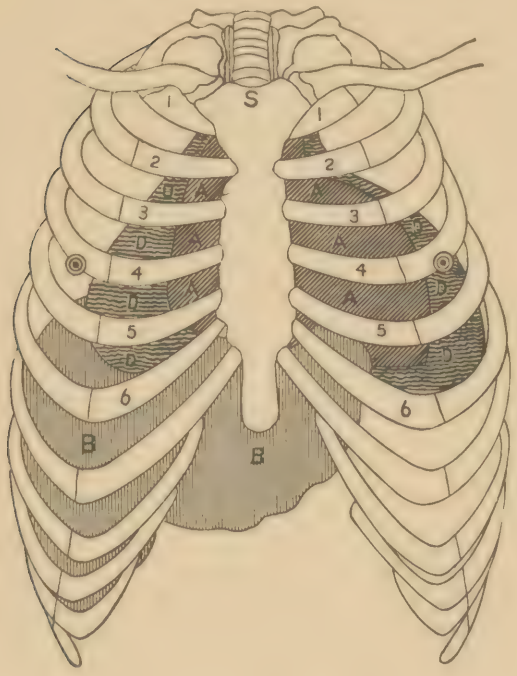
—Nipple.

1, 2, 3, 4, 5, 6—Ribs.

– – – Broken line—Border of lung.

DIAGRAM II.

THE LUNGS HAVE BEEN REMOVED.



A—Normal shape of the heart in its pericardium.

B—Liver.

D—Effusion.

A + D—The shape which the pericardium resumed, in a case where considerable fluid had been introduced into the sack.

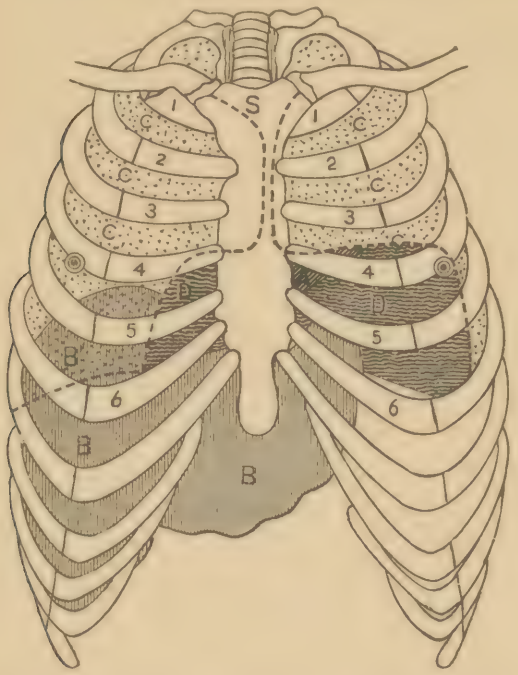
S—Sternum.

—Nipple.

1, 2, 3, 4, 5, 6—Ribs.

DIAGRAM III.

A Small Amount of Liquid has been Introduced into the Sack.



A —The portion of the area of flatness which is still caused by the physiological flatness of the heart.

B —Liver.

B́ —That portion of the liver which is covered by the right lung.

C —Lung.

D —Effusion.

A : **D**—Area of percussion flatness found when the effusion is small.

S—Sternum.

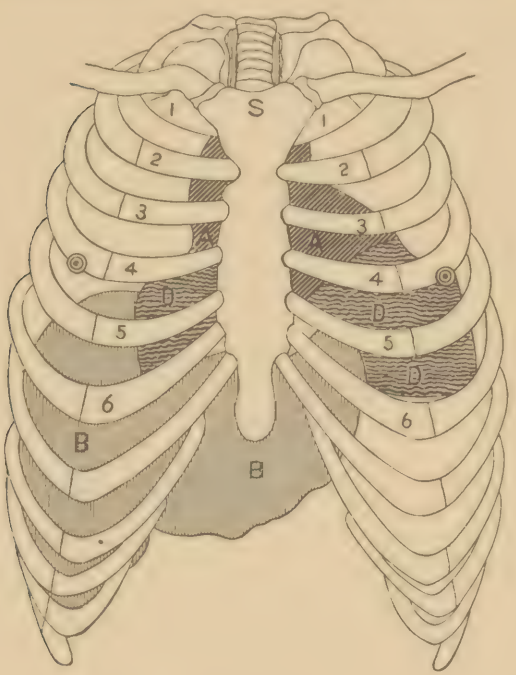
—Nipple.

1, 2, 3, 4, 5, 6—Ribs.

– – – Broken line—Border of lung.

DIAGRAM IV.

REPRESENTS DIAGRAM III. WITH THE LUNGS REMOVED.



A—A portion of the normal heart enclosed in the pericardium.

B—Liver.

D—Effusion as it appeared in the sack, the cocoa butter being in small amount, and the lungs having been removed, after the butter had hardened.

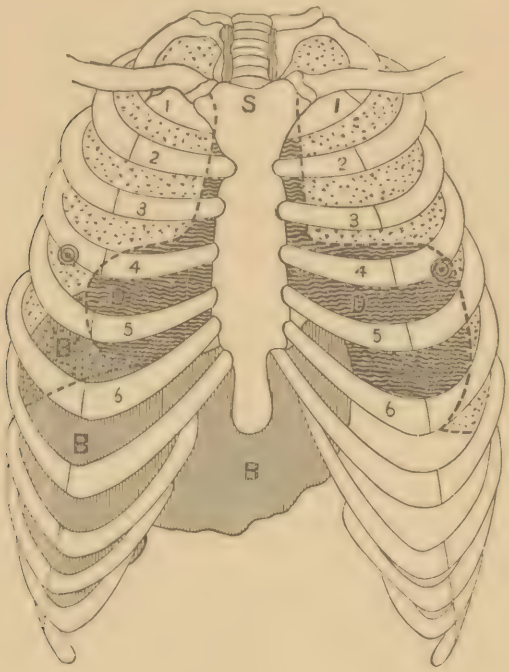
S—Sternum.

◎—Nipple.

1, 2, 3, 4, 5, 6—Ribs.

DIAGRAM V.

A Large Amount of Liquid has been Introduced into the Sack.



B —Liver.

B́ —That portion of the liver which is covered by the right lung.

C —Lung.

D —The area of percussion flatness caused by a large effusion.

S—Sternum.

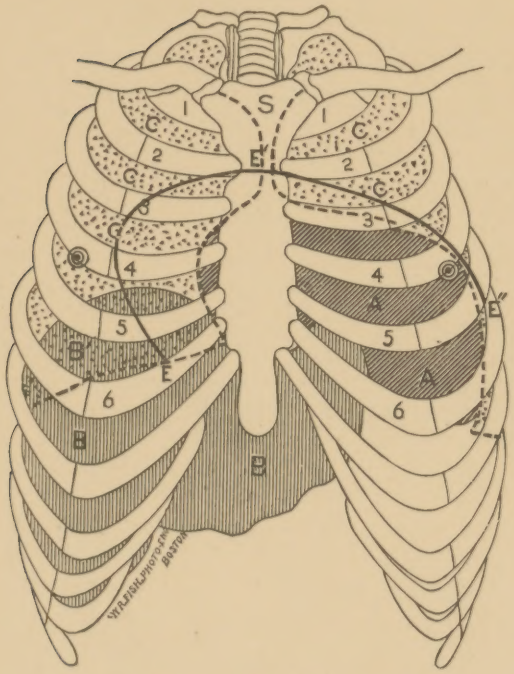
—Nipple.

1, 2, 3, 4, 5, 6—Ribs.

– – Broken line—Border of lung.

DIAGRAM VI.

Enlarged Heart.



A—Area of percussion flatness caused by an enlarged heart.

B—Liver.

B́—That portion of the liver which is covered by the right lung.

C—Lung.

E E′ E″—The line marking the area of relative dulness of the enlarged heart.

S—Sternum.

◎—Nipple.

1, 2, 3, 4, 5, 6—Ribs.

- - - Broken line—Border of lung.